PYRITE FROM CORNWALL, LEBANON COUNTY, PENNSYLVANIA.

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(*Received June 22, 1906.*)

Several varieties of pyrite have been described from the Cornwall magnetite mines. Dr. Carl Hintze[1] mentions three,—(1) a combination of (111) and (100) without a reference; (2) a combination of (100), (111), (210), (321), (432), (221) containing 2 per cent. cobalt;[2] and (3) another variety for which no forms are given, but whose analysis shows 2.39 per cent. copper.[3]

The present paper is a crystallographic study of two varieties of Cornwall pyrite, which will be called Type I and Type II respectively. Type II is identical with the second variety of Hintze, the cobaltiferous; a rough analysis showed 1 per cent. cobalt, and all of the above given forms except (432) were found. Type I, on the other hand, shows no copper nor cobalt, and cannot be identified with any of the above. Apparently it has not been described before.

Occurrence.—Type II occurs scattered through the ore body itself. Crystals of this type grow in cavities in the magnetite, or in what apparently once were cavities. Byssolite and chlorite are commonly found with them. Where the ore is lean, the pyrite crystals are more numerous and are arranged roughly in layers.

The magnetite rests against limestone, which is altered at the contact. Just beyond the contact, in the limestone, Type I occurs, certain thin layers in the rock near the contact and parallel to it being rich with pyrite of this type. The crystals are so crowded in these layers that they largely interfere with each other's growth and perfect crystals are rare.

[1] "Handbuch der Mineralogie," Vol. I (1900), p. 964.
[2] Blake in Dana's "Mineralogy" (1868), p. 63.
[3] Booth in Dana's "Mineralogy" (1855), p. 55.

Type I.

In habit Type I is a combination of (111) and (210), (111) being more developed. The pyritohedron (210) appears in all degrees of development from tiny triangular faces at the corners of the octahedron to equilibrium with it. The trisoctahedron (221) is common and seems to vary with (210), those crystals that have a small pyritohedron face having little or no trisoctahedron. This is not, however, true in all cases. The cube is comparatively rare.

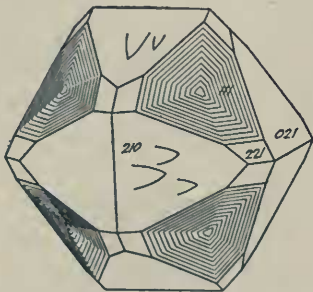

Fig. 1. Type I.

The faces in general are fresh and brilliant. Crystals from the weathered portions show a brown tarnish, which is removed by hot hydrochloric acid, leaving the crystal as bright as fresh material. The octahedron is striated parallel to its intersection with (210) and (221), producing six-sided figures. The pyritohedron has growth figures on its surface, in the form of curved isoceles triangles, whose sides are apparently the intersection of (210) with all possible trisoctahedrons from (221) to (111).

The cube, when present, is the most perfect face on the crystal, and is absolutely without striation. This may be partly due to the fact that it is never very large, and is usually a narrow face beveling the edge of the pyritohedrons. Fig. 1 illustrates the general habit of Type I, and makes an attempt to show the striation and growth figures. The crystals of Type I are, in general, small, few exceeding 0.5 cm. in diameter.

On a series of fifteen crystals of Type I the following forms were observed. Those marked (*) are new for pyrite, and one (14.11.8) has been reported from but one other locality, namely Kotterbach.[1]

[1] K. Zimanyi in Groth's *Zeitschrift*, Vol. 39 (1903), p. 125.

	Trisoctahedrons.	Diploids.
(100)	(331)	(531)
(111)	*(11.11.4)	(321)
(210)	*(552)	*(753)
	*(773)	(432)
	(221)	(14.11.8)
	*(774)	(421)
	(553)	(13.7.3)
	(332)	*(952)
	*(443)	*(14.9.3)
	*(554)	*(542)
	*(665)	

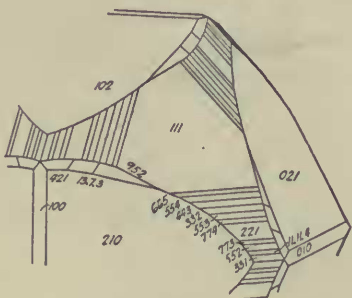

FIG. 2. Type I. Showing trisoctohedrons.

The observations determining these forms are as follows:

(331) was observed on crystal 2 with two faces in the same zone. The better one is about 0.1 mm. wide, and gives the measurement

331 ∧ 221.

Measured .... 6° 07′
Calculated .... 6° 12½′

The second face gives a much poorer image,—

Measured .... 5½° about; signal very poor.

(11.11.4), a new form for pyrite, was observed on crystal 7 with two faces, each about 0.2 mm. wide.

11.11.4 ∧ 111.

Measured .... 20° 48′
Measured .... 20° 51′
Calculated .... 20° 54′

(552), a new form for pyrite, was observed on three crystals, numbers 6, 7 and 10. Numbers 7 and 10 afford the best measurements.

552 ∧ 111.

Measured	19° 25′	(No. 7.)
Measured	19° 10′	(Two faces on No. 10)
Measured	19° 34′	
Calculated	19° 28′	

The measurements on crystal 6 are near enough to identify the form after its presence has been established by the above,—

Measured	19° 03′
Measured	19° 02′

(Two faces on No. 6, measured by direct observation on the face, which was too narrow to give a visible reflection.)

(773) One face of this form (new for pyrite) was observed on crystal 10. The face is quite narrow (0.1 mm.), but is sharp and gives a reasonably good reflection.

773 ∧ 111.

Measured	18° 28′
Calculated	18° 24′

(221) is a common form, and was observed on all the crystals measured,—

221 ∧ 111.

Measured	15° 54′	
Measured	15° 58′	(on various crystals;
Measured	15° 42′	signal generally good)
Measured	15° 46′	
	etc.	
Calculated	15° 47½′	

(This observation shows the degree of accuracy to be expected in the present work.)

(774), a new form for pyrite, was observed on crystal 3, with one narrow face between (221) and (111).

774 ∧ 111.

Measured	13° 05′	(signal rather good)
Calculated	13° 16′	

(553), observed on crystals 1 and 7.

553 ∧ 111.

Measured	12° 22′	(No. 1, signal poor)
Measured	12° 14′	(No. 7)
Calculated	12° 16′	

(332), observed on crystal 1. The zone containing it is somewhat rounded between (221) and (111), and gives by reflection a continuous band. The two principal faces in the zone (332) and (553), however, give distinct, measurable reflections.

332 ∧ 111.

Measured .... 10° 00′ (signal poor)
Calculated .... 10° 1½′

This close agreement, however, must be regarded as accidental.

(443), a new form for pyrite, was observed on crystals 6 and 10.

443 ∧ 111.

Measured .... 7° 28′ (No. 6)
Measured .... 7° 05′ (No. 10)
Calculated .... 7° 20′

(554), a new form, was observed on crystals 1 and 6, with one face on each. The form is small but distinct.

554 ∧ 111.

Measured .... 5° 46′ (No. 1)
Calculated .... 5° 46′

554 ∧ 221.

Measured .... 10° 2′ (No. 6, mean of two reflections at 9° 49′ and 10° 15′ from 221)
Calculated .... 10° 1½′

The agreement, curiously enough, is exact in each case, but this must be accidental.

(665), a new form, was observed as one small face on crystal 10.

665 ∧ 111.

Measured .... 4° 35′ (signal rather good)
Calculated .... 4° 45′

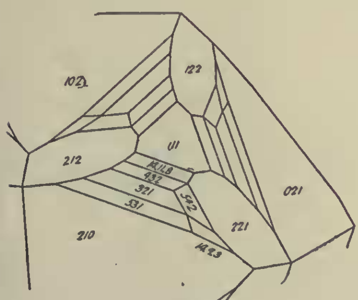

Fig. 3. Type I.

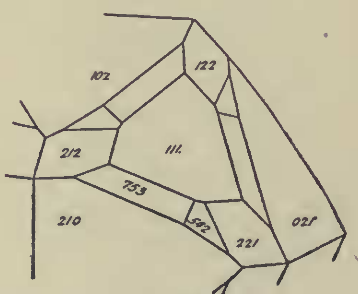

Fig. 4. Type I.

The diploids (421) (13.7.3) and (952) in the zone (112) appear as small, bright, triangular faces between (111) and (210), cutting off the upper corner of the latter face. Considerable difficulty was experienced in measuring them, as they were brilliant only when quite small; the larger faces were poor and rounded.

(421) Only one face was observed; crystal 6 shows a small face whose intersection with (210) is sensibly parallel with the centre line of the latter. It is about 1 mm. long by 0.5 mm. wide.

421 ∧ 111.

Measured	28° 12′
Calculated	28° 6½′

(13.7.3) was found to be common. The form was determined from crystals 10 and 5.

13.7.3 ∧ 210.

	ρ	ϕ	
Measured	8° 30′	11° 30′	(No. 10; signal good)
Measured	7° 55′	11° 49′	(No. 5; signal poor and divided into two. Angle given is mean position)
Calculated	8° 29′	11° 37′	

Other good measurements are

13.7.3 ∧ $2\bar{1}0$.

	ρ	ϕ	
Measured	14° 05′	55° 40′	(No. 8; signal rather bright, but poor)
Calculated	13° 57′	55° 40′	

13.7.3 ∧ 100.

	ρ	ϕ	
Measured	23° 00′	30° 22′	(No. 14)
Calculated	23° 12′	30° 22′	

Besides the above, (13.7.3) was observed on crystal 13.

(952) is a new form for pyrite. It affords smaller faces than (13.7.3) and while bright their smallness prevents any accuracy in measurement. The form was determined from two sets of measurements on crystals 4 and 14.

952 ∧ 210.

	ρ	ϕ	
Measured	11° 40′	11° 15′	(No. 4; signal faint)
Calculated	12° 36′	11° 15′	

As a difference of 1° in ρ is equivalent to 12′ in actual position, the above discrepancy is about 11′.

952 ∧ 001.

	ρ	ϕ	
Measured	28° 45′	79° 06′	(No. 14; signal poor)
Calculated	29° 03′	79° 12′	

(952) was also observed on crystals 5, 9, 10, and 12, giving measurements sufficiently good to identify the form after its occurrence had been established by the above.

The diploids (531), (321), (753), (432) and (14.11.8) in the zone (1$\bar{2}$1) between (210) and (111) were definitely observed on only two crystals, Nos. 11 and 15.

(531), observed on crystal 11 as one face about 0.5 mm. wide by 1.0 mm. long.

531 ∧ 111.
Measured .... 28° 38′ (signal good)
Calculated .... 28° 34′

(321), observed on the same crystal as a comparatively large face, 1 mm. by 1 mm.

321 ∧ 111.
Measured .... 22° 18′ (signal brilliant and
Calculated .... 22° 12½′ good)

(753), a new face for pyrite, was observed on crystal 15 only. The face is about 0.5 by 0.2 mm., and is quite good and bright.

753 ∧ 111.
Measured .... 18° 05′ (signal good)
Calculated .... 18° 5½′

(432) was definitely observed on crystal 11. It appears as a narrow face, somewhat rounded, about 0.1 mm. wide, being less than half the width of the face (14.11.8) occurring in the same zone.

432 ∧ 111.
Measured .... 15° 11′ (signal rather bright but
Calculated .... 15° 13½′ poor)

(14.11.8) appears as a good, brilliant face about 0.3 mm. wide, on crystal 11.

14.11.8 ∧ 111.
Measured .... 12° 32′ (signal bright and fairly
Calculated .... 12° 32′ good)

(14.9.3), a new form for pyrite, occurs as a good face about 0.5 mm. wide on crystal 11. Its symbol was determined from measurement to two adjacent faces, as follows,—

	14.9.3 ∧ 111.	14.9.3 ∧ 221.	
Measured	15° 01′	27° 28′	(signal bright and good)
Calculated	15° 01′	27° 26′	

(542), a new form for pyrite, was observed on crystals 6, 11, and 15. In each case the face was small but bright.

542 ∧ 111.	ρ	φ	
Measured	33° 55′	21° 16′	(No. 6; signal faint but
Calculated	33° 57′	21° 03′	good)

(In the zone or (221) and (321).)

542∧221.

Measured	....	6°	(No. 11; signal good)
Measured	....	6° 13′	(No. 15)
Calculated	....	6° 24′	

The faces observed on each crystal are set forth in the following table:

Form.	Crystal No.														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
100		*								*			*	*	*
111	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
210	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
331		+													
11.11.4							+								
552						*	+			+					
773										+					
221	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
774			+												
553	+						+								
332	+														
443						+				+					
554	+					+									
665										+					
531											+				
321		?									+				
753															+
432		?									+				
14.11.8											+				
421			+												
13.7.3					+			+		+			*	+	
952				+	*				*	*		*		+	
14.9.3											+				
542						+					+				+

(* indicates that the measurements were used to determine the form and are given above under the description of faces.)

A detailed description of the fifteen crystals measured is unnecessary, but several crystals will be taken up in detail to give an idea of the relative prominence of the observed forms.

Crystal 4 is a typical crystal illustrating (952). It is a fragment, less than half of a complete crystal, about 4 mm. long. It shows one end of a cubic axis, with parts of four octahedron faces and two (210) faces, the larger of the latter being 3 mm. by 1.5 mm. and the other about half that size. One trisoctahedron face is present; if the larger pyritohedron is called (102) this trisoctahedron will be (122). It is about 0.5 mm. wide. The face (529) appears cutting off the corner at the junction of (102), (122) and (111). It is 0.5 mm. by 0.1 mm. and very perfect and bright.

Crystal 10 may be taken as typical of those showing the various trisoctahedrons well developed. It is a fragment about 5 mm. in diameter. It shows two complete pyritohedron faces each about 2 mm. wide. If we put them in the position of (102) and $(\bar{1}02)$ respectively, the other faces developed will be these,—about half of (021) and a small part of (021). The zone $(\bar{2}10)$, $(\bar{1}00)$ and $(\bar{2}\bar{1}0)$ appears, showing a small fragment of these faces. This is the only appearance of the cube on the crystal. The octahedron appears as small portions of the four upper faces. Three trisoctahedron zones appear, (221) being most prominent and giving faces about 1 mm. wide.

One of these zones shows two small faces occupying the position of (552) or (331); they are too minute to give a reflection. The next zone is rich in faces. Starting with the octahedron having the position $(1\bar{1}1)$, we have in order, $(1\bar{1}1)$, $(5\bar{6}6)$, $(1\bar{2}2)$, $(3\bar{7}7)$ on one side, and on the other $(\bar{2}55)$, $(\bar{1}\bar{2}2)$, $(\bar{1}\bar{1}1)$. The two (221) faces are about 0.5 mm. wide; the other trisoctahedrons uniformly about 0.1 mm. The third zone is similar, but shows two faces of (552) instead of one of (552) and one of (773), and a face of (443) instead of (665).

Two diploid faces are present, in the positions (529) and $(7.\bar{3}.13)$. The face of (952) is extremely small and bright, and cuts off the corner formed by (102), (111), and (122). The face of (13.7.3) is larger,—1 mm. long by 0.2 mm. wide,—and rounds off into the adjacent octahedron face, the rounded part being a conical surface. This rounding off was often noticed on (13.7.3) but not on (952).

Crystal 11 shows a rare combination of forms. It diverges remarkably from the type, and indeed might have been supposed to come from another locality, were it not for the perfectly typical markings on the pyritohedron and octahedron. Again, one of the forms it shows, (542), is found on crystals 6 and 15, which are perfectly typical in all respects. It is a rough fragment 1.5 cm. long, showing on one end an octahedron face with two adjacent (221) faces, and one face each of (321), (542), (14.11.8), (432), (14.7.3). A rough curved, irregular surface breaks the (111, 210) zone beyond (321) for the space of 2 mm.; (521) and (210) appear beyond this irregular portion. The octahedron and (221) faces are each a couple of mm. in extent; the face of (321) is 1 mm. each way, and

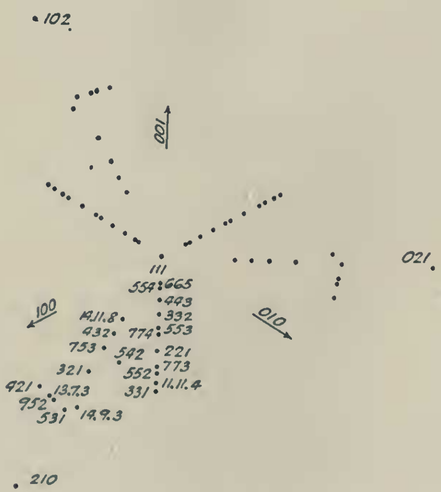

FIG. 5. Type I. Gnomonic projection on plane of octahedron. Illustrating zonal relations.

the (14.7.3) and (531) faces are 0.5 mm. wide; (14.11.8) and (542) are about 0.3 mm. wide, and (432) about 0.1 mm. If the pyritohedron be regarded as (102), the observed faces have the positions, (102), ($1\bar{1}1$), ($2\bar{1}2$), ($1\bar{2}2$), ($3\bar{1}5$), ($2\bar{1}3$), ($3\bar{2}4$), ($11.\bar{8}.14$), ($4\bar{2}5$), and ($9.\bar{3}.14$). Fig. 3 shows the combination of forms observed on this crystal.

Crystal 15 shows two octahedron faces, (111) and $(1\bar{1}1)$, and a portion of (102). One face of the trisoctahedron is present, in the position (212). It is a trifle less than 1 mm. wide. (537) lies in the zone of (111) and (102); it is about 0.5 mm. by 0.2 mm. in extent. (425) appears as a nearly equilateral triangle about 0.2 mm. on a side between (212), (537) and $(1\bar{1}1)$. A portion of (210) is present below (212). (425) lies in the zone (210, 212). Fig. 4 shows this combination of forms.

Zonal Relations of Type I.

The zone of trisoctahedrons, symbol $(1\bar{1}0)$, seems to be the most important in this type. It affords the greatest number of forms, and determines the growth figures on the pyritohedron face and the direction of one set of striations on the octahedrons.

The zone of (111) and (210), symbol $(1\bar{2}1)$, which is usually well developed in pyrite, seems to be of secondary importance in this type. While it determines the second set of octahedral striations, it was only observed on three crystals,—2, 11, and 15. On the last two of these, however, it affords a good series of forms, (531), (321), (753), (432), and (14.11.8).

The zone $(\bar{1}12)$ is important, affording (421), (13.7.3), (952) and (531), but curiously enough only a single face of this zone appears at a time. The primary importance of the zone of trisoctahedrons again appears in the fact that each of the above faces lies between (210) and a trisoctahedron of simple ratio, thus,—

210	210	210		210
421	13.7.3	952	and	531
212	323	434		111

This is also true of the scattering diploids (14.9.3) and (542).

210	210
14.9.3	542
443	332

These trisoctahedrons have the same ratio as the ones above, but are in a different zone.

The occurrence of the zone of trisoctahedrons as an important zone is so rare in pyrite that the writer has been moved to call this type the "trisoctahedral type." While a number of trisoctahedrons have been described on pyrite, their occurrence is usually scattering, one or two from each locality, and not in a complete series, as in the present case.

It will be noticed that the general shape of the crystal as indicated by Fig. 1 approaches a sphere, pointing to growth under great pressure.

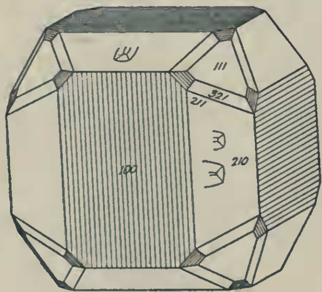

FIG. 6. Type II.

TYPE II.

This type affords larger and more perfect crystals, which often attain a diameter of 2 or 3 cm. In habit the crystal is a combination of cube and pyritohedron (210) with the octahedron, the diploid (321) and the trapezohedron (211) commonly occurring. The cube is striated in the usual manner for pyrite, parallel to the intersection with (210), and the (211) face is striated parallel to its intersection with the octahedron. Large natural etching figures are common on the cube, approximately square, in diagonal position. There is reason to believe that the striation on (211) is due to natural etching and not to growth. The pyritohedron has growth figures as shown in Fig. 6. With the exception of the cube and trapezohedron the faces are in general fresh and lustrous.

A series of seven crystals was measured, and the following forms observed. Those marked (*) are new for pyrite. In addition, two forms (15.11.7) and (11.8.5) have been previously observed from but one locality,—Porkura.[1]

[1] B. Mauritz in Groth's *Zeitschrift*, Vol. 39 (1903), p. 357.

	Diploids.	Trisoctahedrons.	Trapezohedrons.
110	321	221	211
210	*753	*774	*744
111	11.8.5	*552	
	15.11.7		
	14.11.8		
	*876		
	*12.11.10		

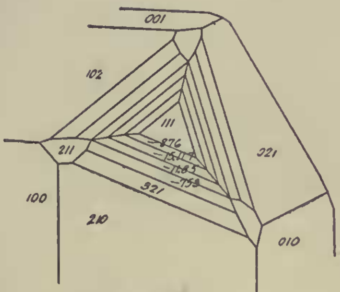

FIG. 7. Type II.

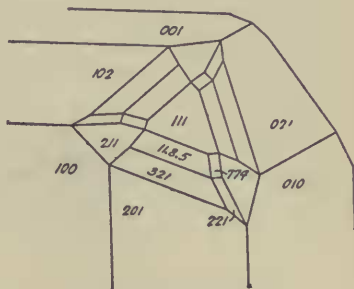

FIG. 8. Type II.

The observations determining these forms are as follows:

(321) was a face commonly observed. Some of the measurements are:

321 ∧ 111.

Measured	22° 14′	(Crystal 22)
Measured	22° 13′	(Crystal 22)
Measured	22° 10′	
	etc.	
Calculated	22° 12½′	

showing the degree of accuracy that may be expected in this type.

(753), a new form, was observed on crystals 23, 26 and 27,—

753 ∧ 111.

Measured	18° 05′	(Crystal 23)
Measured	17° 58′	(Crystal 26)
Calculated	18° 05½′	

753 ∧ 321.

Measured	4° 05′	(Crystal 27)
Calculated	4° 07′	

It is almost unnecessary to state that the above, as well as all other diploids observed on this type, were found to be sensibly in the zone of (111) and (210), so that one angle from the octahedron determines them.

(11.8.5) was observed as one narrow face on crystal 21, and two fairly good faces on crystal 23.

11.8.5 ∧ 111.

Measured	17° 05′	(Crystal 21; signal poor and faint)
Measured	16° 59′	(Crystal 23; signal good)
Calculated	17° 01½′	

(15.11.7) was observed as one face on crystal 25. The face is quite good and is about 1 mm. wide.

15.11.7 ∧ 111.

Measured	16° 33′	(signal good)
Calculated	16° 32′	

(14.11.8) was observed once only on this type, on crystal 26. The face is about 0.2 mm. wide.

14.11.8 ∧ 111.

Measured	12° 37′
Calculated	12° 33′

(876) was observed as one good face about 0.7 mm. wide, on crystal 23.

876 ∧ 111.

Measured	6° 44′
Calculated	6° 39′

(12.11.10), a new form, may almost be regarded as vicinal. On crystal 26 the following measurement was obtained:

12.11.10 ∧ 111.

Measured	4° 19′	(signal poor)
Calculated	4° 15′	

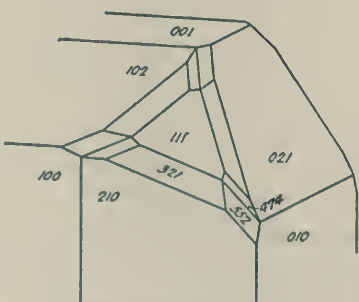

Fig. 9. Type II.

(221) and **(774)** were observed on crystal 23. They were extremely narrow faces, each lying in a zone with (211) and a diploid. Their narrowness prevented their giving any definite signal, but they were very perfect and gave fairly good results by direct observation, that is with the small auxiliary lens down in front of the telescope objective. There was no doubt as to the diploid determining (211). It gave,—

321 ∧ 111.

Measured	22° 13′
Calculated	22° 12½′

but the one determining (774), that is (11.8.5), was not definite. This problem was solved by measuring the angle between the zones (211)(774) and (211)(111) on a petrographical microscope reading angles to 5′.

121 ∧ 221.

Measured	11° 36′
Calculated	11° 30′

121 ∧ 774.

	ρ	φ
Measured	43° 39′	17° 01′
Calculated	44° 01′	17° 05′

The remaining trisoctahedron (552) will be discussed along with the trapezohedron (744) for a special reason.

(211) is of common occurrence and cannot be mistaken, on account of its striation. It usually gives a poor reflection. A measurement on crystal 22, however, gives,—

211 ∧ 111.

Measured	19° 28′
Calculated	19° 28′

(744) and **(552)** were observed on crystal 24. The pyritohedron (210) and the octahedron are present, and two faces of (321), one of which lies in a zone with (210) and (111). The two faces considered lie in a zone with (210) and the other diploid face (132). They are both extremely narrow, (744) not being wide enough to afford a satisfactory signal, and requiring measurement by direct observation.

	210 ∧ 474.	210 ∧ 552.
Measured	42° 23′	23° 48′
Calculated	41° 49′	24° 06′

There is considerable discrepancy here, (474) in particular being half a degree out. This is very probably due to the inaccuracy of the method by which it was measured. It is much more probable that the faces have the symbol given than that they are diploids with complex ratios approaching these symbols, for two other trisoctahedrons have been observed, (221) and (774), and one other trapezohedron (211), while no diploids were observed except in the zone of (111, 210).

It will be noticed that one form given by Blake, namely (432), was not observed,—a form with simple ratio, and one which if it occurred at all would be more common than forms of more complex ratios, as (15.11.7) and (11.8.5) There is some doubt in the writer's mind as to whether the (432) of Blake really is (432) or is a diploid with more complex ratio, as the above.

The following table sets forth the forms observed on each crystal.

Form.	Crystal No.						
	21	22	23	24	25	26	27
100	*	*	*	*	*	*	*
210	*	*	*	*	*	*	*
111	*	*	*	*	*	*	*
321	*	*	*	*	*	*	*
753			*			*	*
11.8.5	*		*				
15.11.7					*		
14.11.8						*	
876			*				
12.11.10						*	
221			*				
774			*				
552				*			
211	*	*	*		*	*	*
744				*			

Crystal 23 is perhaps the only one of this series worthy of a separate description. This crystal is about 1.8 cm. in diameter. It shows the cube (100) with its adjacent pyritohedron faces (210) and (2̄10), and (001) with (102). There are two octahedron faces, (111) and (11̄1). The former face, which is surrounded by the zones containing the new diploids, would have been 3 mm. on a side, but another smaller crystal has grown into it, leaving only two corners. Of the three zones of diploids that surround (111), one has two faces in it, (11.8.5) and (321); the second three, (876) (11.8.5); and the third two, (753) and (321). The (876) and (753) faces are about 0.7 mm. wide, and the (11.8.5) face in the second zone is 1 mm. wide. All are perfect faces. The (11.8.5) zone is good at one end, but at the other runs off into a broken vicinal face. At its good end is a face of (211), about 1 mm. long. Between this latter and the (11.8.5) and (321) faces lie the trisoctahedrons (221) and (774) described above.

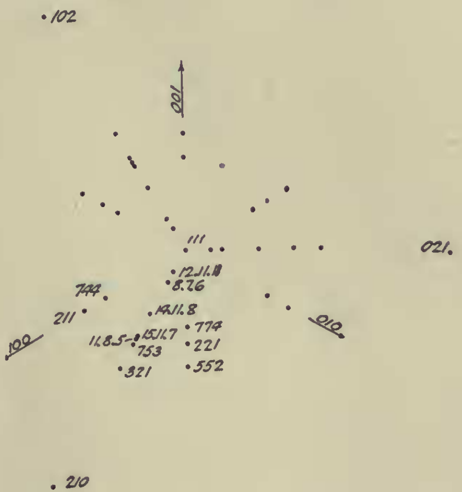

Fig. 10. Type II. Gnomonic projection on plane of octahedron. Illustrating zonal relations.

Zonal Relations of Type II.

The most important zone in this type, outside of the cube-pyritohedron zone, is that of the octahedron and pyritohedron, symbol (12̄1). This affords all the observed diploids, seven in number, one of which (321) is practically always present. The trisoctahedron zone was developed on one crystal, affording (221) and (774), each of which was in a zone with (211) and an observed diploid. Thus,—

211	211
212	747
213	8.5.11

This is not true of (552), which would agree with the diploid (741). No diploids were observed between (321) and (210), (321) being the last of the series.

The development of the zone between the pyritohedron and a non-adjacent (321) face, e. g., (210) (132) on crystal 24 is probably accidental, due to the irregular development of the crystal. This zone affords (552) and (474).

The writer wishes to call attention to the method described above, used in determining the small faces (221) and (774). He has not heard of its previous use as a practical method of measurement. The angle ρ can be measured to within 5′ or 10′ with a microscope, and this is accurate enough for all purposes if ϕ is not large. The easiest way of holding the crystal on the stage is to set it on a cone of wax on a glass slip; the face chosen as a reference face can be made approximately horizontal by hand. Having measured ρ, the crystal can be set up on an ordinary one-circle goniometer, and, using the Websky signal, ϕ may be measured by observing the face directly and finding the point of maximum brilliancy of reflection.

In concluding, the writer wishes to express his indebtedness to Professor Amos P. Brown, not only for the specimens which furnished the material for this paper, but also for valuable assistance in its preparation. Thanks are also due to Mr. Kenneth Williams for crystals of Type II used in the above series.